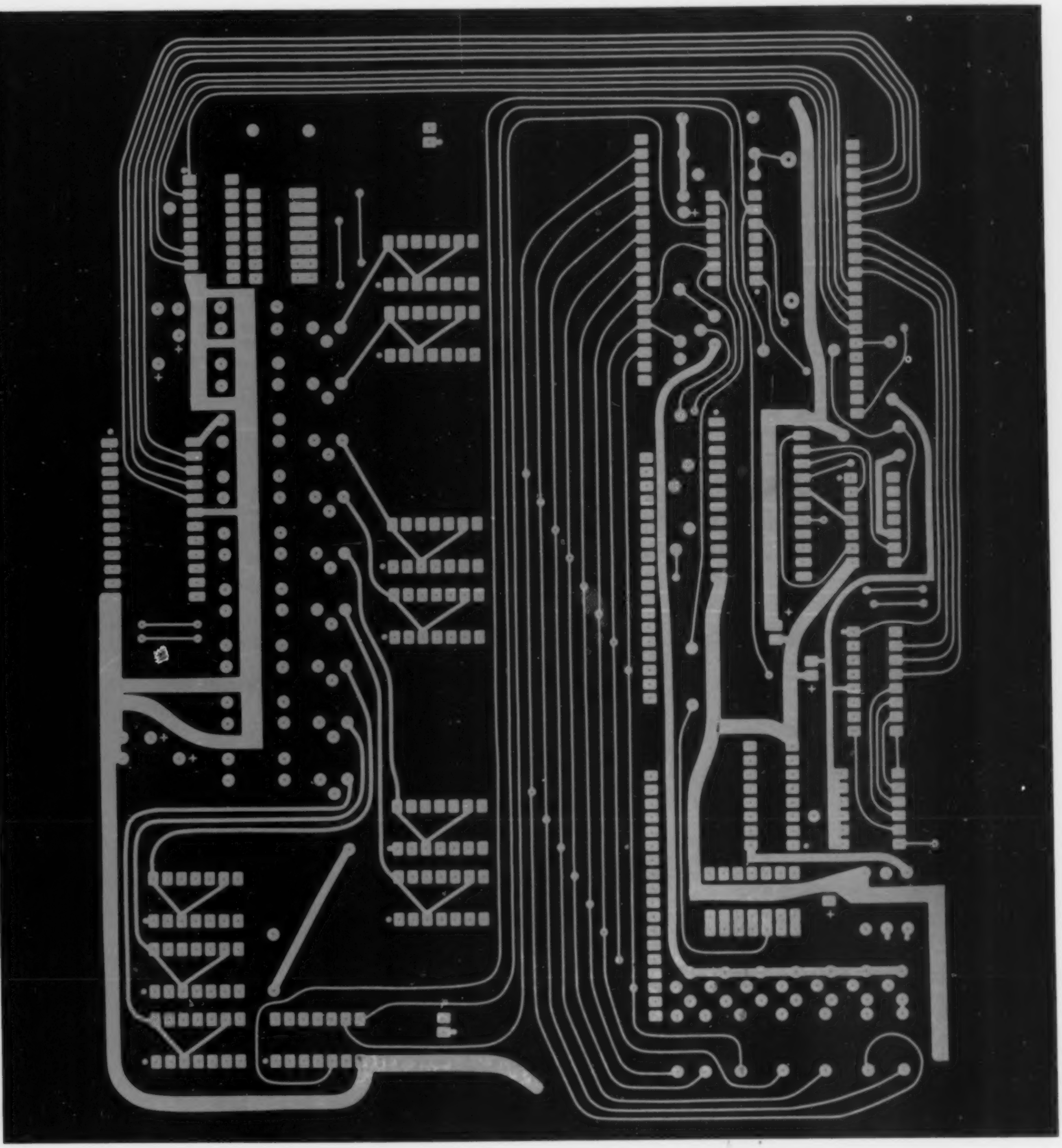
DIMENSIONS NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

October 1977



INVENTION. See page 3.

COMMENT

TOWARD AN INTERDISCIPLINARY TECHNOLOGY

Today, as never before, the results of research are rapidly incorporated into new technology. New and improved industrial processes, products, techniques of medical practice and laboratory analysis not only quickly follow scientific discovery, but also increasingly draw upon the results of many disciplines.

Consider, for example, nuclear power. The reactor design engineer must have an understanding of strength of materials over a wide range of temperature, heat transfer mechanisms, chemical processes leading to corrosion, effects of ionizing radiation damage on materials, and many esoteric nuclear reaction and energy deposition processes occurring in these materials, just to mention a few.

In the biomedical area, researchers and clinicians now require expertise in such modern techniques as x-ray diffraction or fluorescence for identification of biochemical substances and processes. Many hospitals now own and operate cyclotrons for production of short-lived radio-pharmaceuticals and accelerators for the treatment of cancer.

These examples merely scratch the surface of a rapidly growing technology which often draws on many fields of science simultaneously. But how does a design engineer obtain the quantitative information on properties of materials he requires from a number of diverse scientific disciplines—disciplines he is largely unfamiliar with? How can the biochemist obtain reliable x-ray diffraction data, or atomic energy level information, to allow interpretation of the results of modern x-ray diffraction or spectral techniques?

The answer to these questions lies in an effective mechanism for producing and disseminating evaluated reference data. The National Bureau of Standards and other government agencies support programs which compile and *critically evaluate* research results in many areas of physics and chemistry. Evaluated data are published periodically on the physical and chemical properties of materials, as are critical reviews of the experimental and theoretical methods used in the determination of these data. Such programs provide engineers and scientists with the specific quantitative information they need, with assurance of its validity.

The rapid growth of interdisciplinary applications of science emphasizes the role of these data evaluation projects as the most effective mechanism for the transfer of quantitative scientific knowledge across disciplines—with confidence in the validity of the data. However, the fact that such programs exist does not make the transfer automatic. Traditionally, a data evaluation program has been familiar to researchers in the same discipline, but rarely did others know of its existence. Indeed, those who carry out the current reference data programs are challenged to discover how to conduct these interactions more effectively. Increased attention to and knowledge of new developments over a wide range of scientific and engineering enterprises will be required, along with new formatting and disseminating procedures which will promote rapid access and ease in the use of these data.

As new technological developments draw more and more on a range of scientific areas, the need for effective programs and vehicles which provide evaluated reference data across the boundaries is also increasing. We must establish these mechanisms as we continue to move toward an interdisciplinary technology.

Sherman P. Fivozinsky
Office of Standard Reference Data
Room A535 Administration Building
National Bureau of Standards
Washington, D.C. 20234
301/921-2104

DIMENSIONS/NBS

*The magazine of the
National Bureau of Standards
U.S. Department of Commerce
Volume 61/Number 10*

October 1977

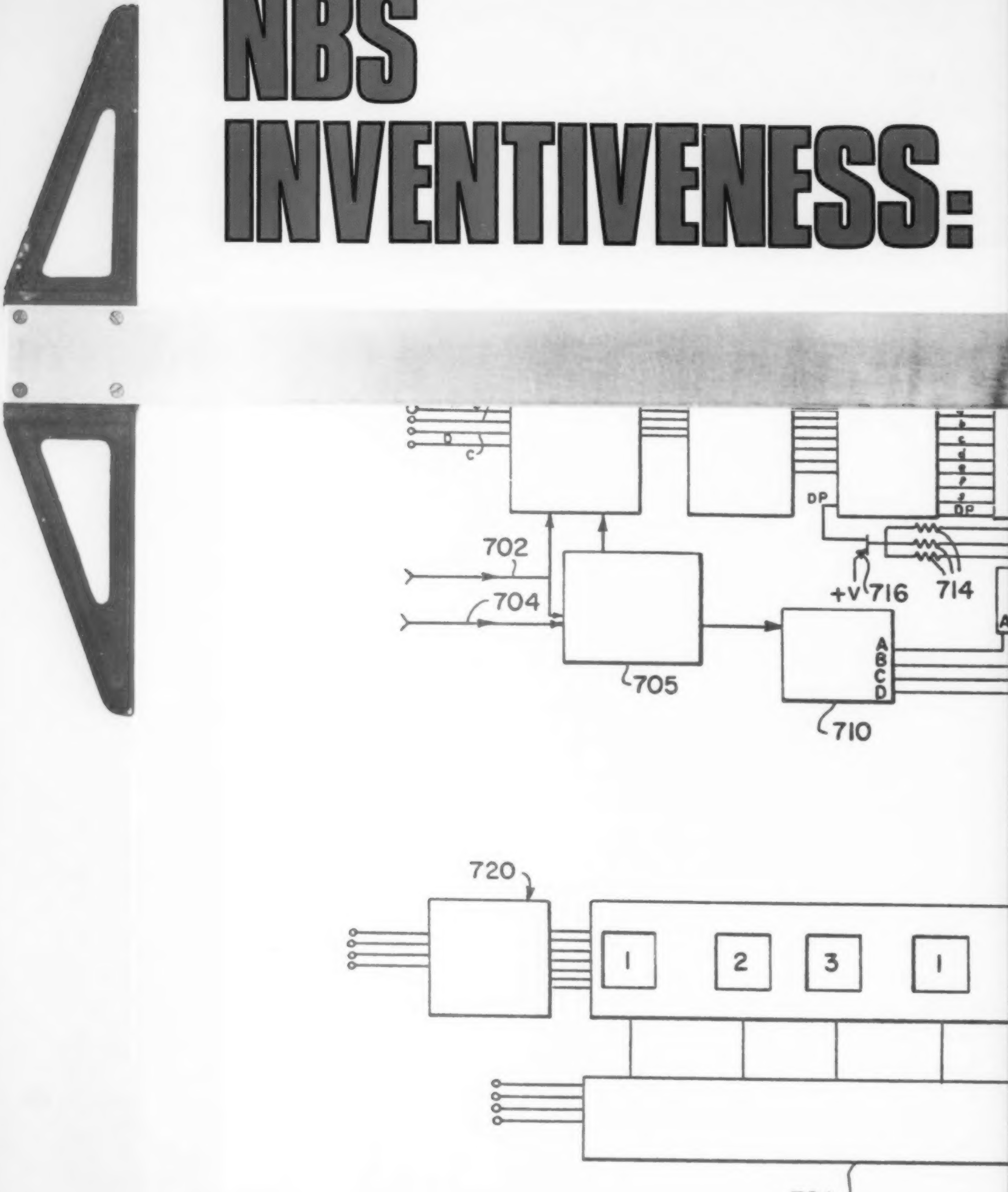
Contents

ARTICLES

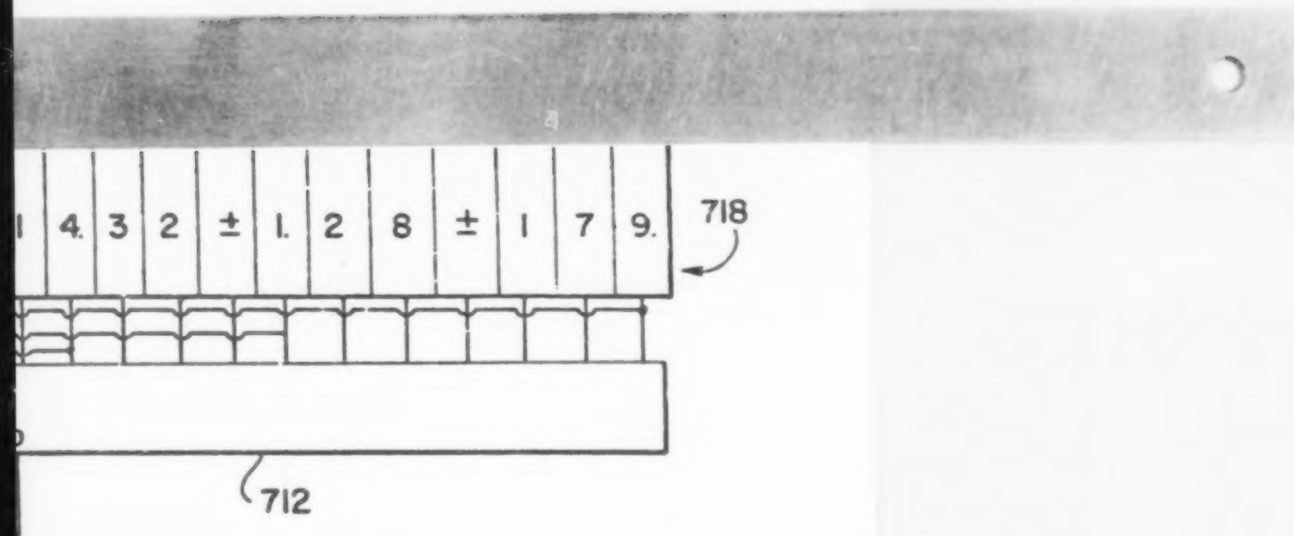
INTERFACE

UPDATE

NBS INVENTIVENESS:



STILL A WINNING COMMODITY



by Michael Baum and Madeleine Jacobs

RESEARCHERS at the National Bureau of Standards have never lacked in ingenuity. Over the years, some of their inventions—like the neon tube and the electromagnetic particle clutch—have launched industries. It was NBS that put radio into the home with the development of the first alternating current radio set. Capitalizing on their expertise in radio technology, the Bureau staff gave the Allies a decided wartime advantage in two forms: a radio proximity fuse that caused a bomb to explode just prior to impact and the first successful guided missile. Soon, while most Americans watch television unaware of any change, millions of hearing-impaired individuals should be enjoying the same programs—with captions added—thanks to a system developed by an NBS engineer.

These and the many other accomplishments achieved by the staff stand on their own merits as tributes to the researchers and to the institution. Some get singled out for special recognition, and this, too, is a source of pride.

This year, inventions for the precise measurement of time and space won three awards for NBS scientists in a nationwide competition sponsored by *Industrial Research* magazine for the 100 most significant new technical products in 1977.

The NBS "I-R-100" winners and their products are

- D. Wayne Hanson, Joseph V. Cateora, and Dick Davis of the NBS Institute for Basic Standards for development of a highly accurate satellite-controlled clock;
- David B. Ballard, Fielding Ogburn and John P. Young of the NBS Institute for Materials Research for development of a micrometer scale for calibrating scanning electron microscopes; and
- John L. Hall of the Institute for Basic Standards, together with Siu-Au Lee of the University of Colorado for development of a laser wavelength meter.

Hanson and co-workers Davis and Cateora contributed to the science of time measurement a novel digital clock system which automatically resets and corrects itself on the basis of a radio time code broadcast from one of two orbiting satellites.

turn page

Baum and Jacobs are writers and public information specialists in the NBS Office of Information Activities.

COVER STORY:

The cover shows a layout of the printed circuit board of the NBS satellite-controlled clock. The clock is one of three NBS inventions cited this year by Industrial Research magazine as among the top 100 new products of 1977.

D. Wayne Hanson (left) and Joseph Cateora inspect the calculator circuits of their space age clock.

Development of the satellite-controlled clock began about two years ago in connection with a time code project undertaken by NBS for the National Oceanic and Atmospheric Administration (NOAA). A coded message including time-of-year and satellite position information is radioed to the orbiting satellite from a station on earth. The information is relayed at a precise data rate from the satellite back to earth.

The satellite transmission can reach much more of the Earth's surface than can signals broadcast from a ground station, and satellite time signals do not suffer from the propagation effects that distort earthbound broadcasts.

The new clock can provide time to within 20 microseconds of the world time standard (Universal Coordinated Time) almost anywhere in the Western Hemisphere using signals from either of NOAA's Geostationary Operational Environmental Satellites.

The new time system is completely automatic. The only system of its kind with that feature, the new clock is invaluable for field and laboratory time synchronization in such areas as communications, electrical power distribution, navigation, surveillance, and environmental and geophysical data-gathering.

The satellite-controlled clock is manufactured by Arbiter Systems of Goleta, California.

The micrometer scale for the scanning electron microscope (SEM) developed by Ballard, Ogburn and Young provides a new capability for magnification calibration of this useful instrument.

Currently, there are more than 3,000 SEM's in use in U.S. research laboratories, involving such topics as the study of air pollution particulates, corrosion of materials, wear of surfaces, fabrication of microelectronics, and examination of microstructure of metals used in electrical energy distribution.

Often the SEM is the only investigative tool that can be used to observe detail in the 2,000 to 40,000 magnification range on the surface of bulk materials of interest. Previously available magnification scales frequently had uncertainties of 10 to 30 percent. The new Standard Reference Material (SRM) developed at NBS reduces the uncertainty to 5 per cent in this magnification range.

The scientists took a unique approach to the fabrication of the SRM. A layer of bright nickel was electroplated onto the surface of a thin monel sheet. Then, alternate layers of bright gold 40 to 80 nanometers thick and bright nickel having nominal thicknesses of 1, 3, 5 and 20 micrometers were deposited under precise control. Small square samples were sheared from the central portion of the composite sheet and mounted on edge in copper-filled epoxy for metallographic polishing. The distances between the observed images of the gold lines are used to calibrate the magnification scale of the SEM. The scientists have filed a patent application for the fabrication process.

The new micrometer scale SRM has many advantages over existing SEM magnification reference materials: improved contrast and uniformity of image, resistance to corrosion, no loss of dimensional integrity if it has to be cleaned due to contamination, no adverse reaction with the elec-

tron beam, and a range of 1 to 50 micrometers in interval size, a marked improvement over other standards with only one interval size.

Individual interval spacings are measured and certified in the new magnification scale, which is sold by the NBS Office of Standard Reference Materials as SRM 484 for $207.

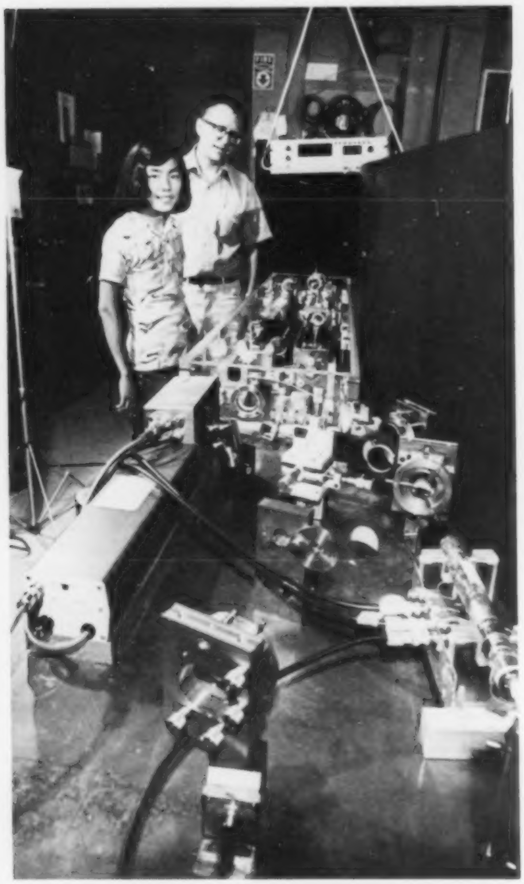
The laser lambda meter built by Hall and Lee grew out of their need to control a continuous wave (cw) dye laser system used by the Joint Institute for Laboratory Astrophysics (JILA), a cooperative project supported by NBS and the University of Colorado.

Like many scientists working in fields such as laser isotope separation, high resolution spectroscopy, laser chemistry, or air pollution measurement, Hall and Lee needed a system that could measure a laser wavelength as accurately and as fast as possible. This allows the laser to be "tuned" to the proper frequency.

Using a system of corner-cube retroflectors to provide an automatic alignment of the laser beams, the lambda meter compares the wavelength of an unknown laser beam with that of a known standard frequency laser and calculates the unknown wavelength from this comparison. The meter gives wavelength readings to seven significant figures at a rate of four measurements per second.

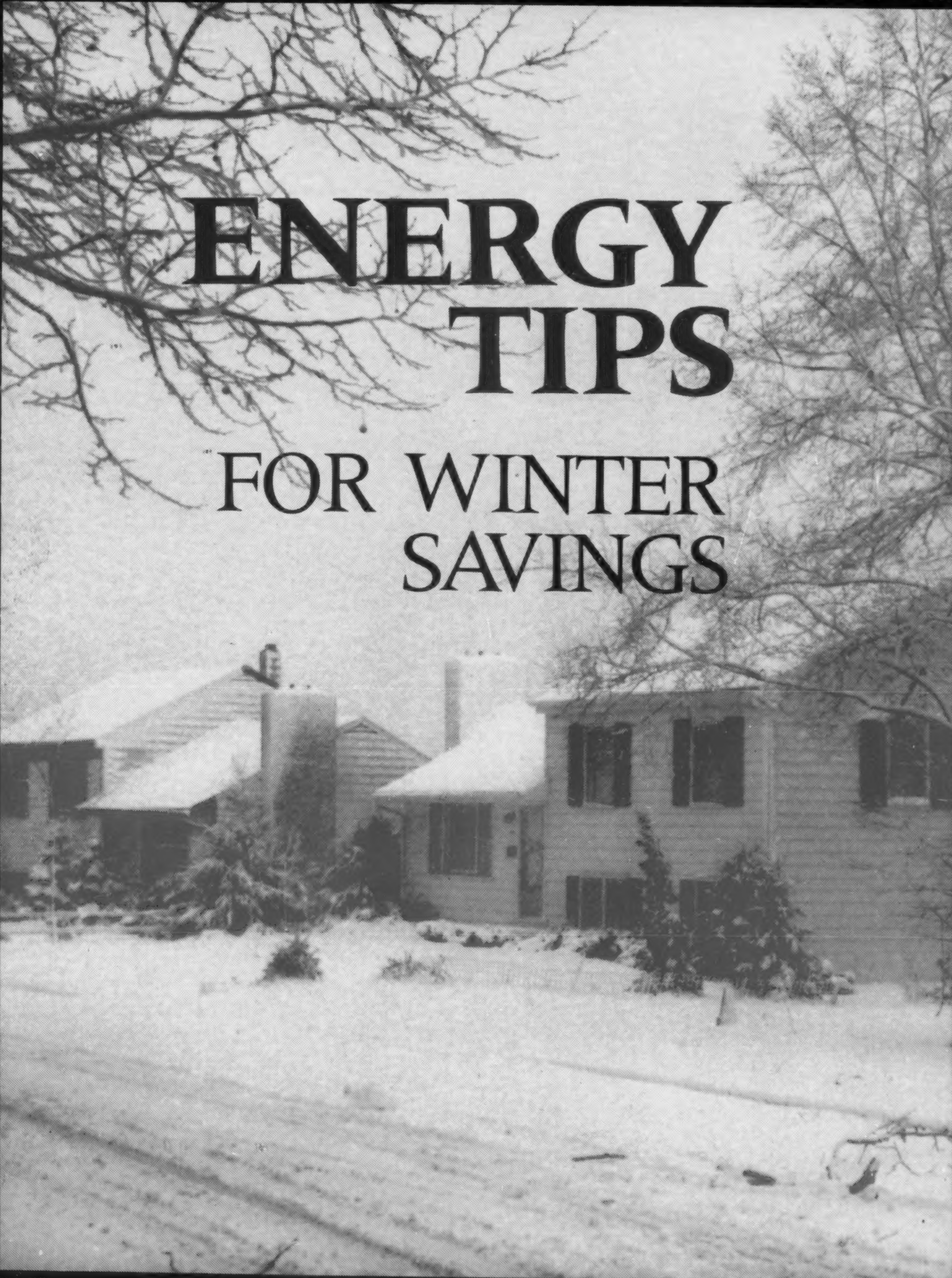
The lambda meter provides digital readout of the wavelength for cw lasers in the visible infrared, and ultraviolet regions. The system is not yet commercially available, but several manufacturers have expressed interest in making it. □

David Ballard uses scanning electron microscope to observe the new micrometer scale he developed with John Young (standing, left) and Fielding Ogburn.



Inventors Siu-Au Lee and John Hall with their laser lambda meter.

ENERGY TIPS FOR WINTER SAVINGS



One of America's biggest concerns is conserving energy. Last winter, many parts of the country experienced the coldest weather in years and homeowners received their highest fuel bills ever. We don't know what kind of weather upcoming winters will bring, but we can be certain that the cost of fuel will continue to rise. Steve Petersen, an energy conservation economist at the National Bureau of Standards, has been examining ways to save the most energy in the home without sacrificing comfort. In the following interview, with NBS writer Susan Lieberman, he makes several recommendations for the energy conscious homeowner.

Question: What are some of the ways to save energy in the home?

Petersen: Two basic approaches can make the home more efficient. The first is to make direct improvements to the shell of the house and the second is to operate the home more efficiently. Improvements to the shell of the house include insulation in the attic, sidewalls, and under the floors over unheated areas; storm windows; storm doors; and weather stripping and caulking around window and door frames.

Q. How much insulation is needed?

A. The amount of insulation depends a lot on the climate conditions and the cost of energy. For example, in the more mild regions of the United States, R–19 insulation in the attic is probably adequate, whereas farther north, more insulation, such as R–38, may be needed. Electrically-heated houses generally should be insulated better than gas or oil-heated houses, because electric heat costs more.

Q. What do R–19 and R–38 mean?

A. "R" values, or resistance values, determine the insulation's ability to decrease heat flow through the shell of the house. Energy savings result from decreasing this heat flow. Therefore, homeowners should buy insulation based on the "R" value and not the thickness of the insulation. The higher the "R" value, the more resistance to heat flow the insulation provides.

Q. What kinds of insulation do you recommend?

A. In general, insulation materials which have a relatively high resistance to heat flow and which are fire and vermin-resistant are best. Batt insulation should be used in attics and sidewalls only if it will fit snugly. If it won't fit snugly, then loose-fill insulation will do a better insulating job.

NBS energy conservation economist Steve Petersen.

Q. When should homeowners test their houses for leaks and try to weather strip?

A. When the wind is blowing, air will leak through cracks around windows and doors and even through electrical outlets. Weatherstripping and caulking can usually reduce or eliminate these leaks.

Q. What kind of storm windows are most energy efficient?

A. One of the best types of storm window available is the triple-track or self-storing window. It should fit tightly but can be easily opened when the outside temperature is sufficient that the windows can be opened for natural ventilation.

Q. How can the house be operated more efficiently?

A. Some operational procedures which make a lot of difference in the amount of energy a house uses include closing off unused rooms, tuning up your furnace every couple of years and changing the filters in the furnace every couple of months, opening shades during the day to let in solar heat and keeping the thermostat set at 18 °C (65 °F) in winter.

Improvements to the shell of the house will also help save energy next summer. The National Bureau of Standards and the Federal Energy Administration have published a guide, *Making the Most of Your Energy Dollars in Home Heating and Cooling*. It has worksheets that can help you determine what kinds of improvements will save the most energy and lower your fuel bills. For a copy, send 70 cents to Consumer Information Center, Department 184, Pueblo, Colorado 81009. □

Harnessing Technology for State and Local Use

by James M. Wyckoff and Gerald E. Miller

THE state fire marshal in Oregon was concerned. A fire had ravaged a jail in Tennessee the previous day, killing over 40 people. One Oregon prison industry manufactured the mattresses used in institutions throughout the state. Were officials up to date on the fire safety of these and other materials? The marshal called the Oregon Technology Transfer Office, which referred him to the National Bureau of Standards. The question was this: "What do you know about the latest technology in fire retardant materials that might be used in prisons?"

The call was referred to the NBS Center for Fire Research. The center had just issued the first reports on a major NBS study concerning bedding flammability. These results and other data were mailed to Oregon the following day, and state officials were able to use the information in plans to improve fire safety in Oregon prisons.

This example illustrates the effectiveness of a new and still embryonic structure for realizing the concept of technology transfer. The aim is to speed technology from developer to user through a system of local, state, and federal communication and cooperation. Usually, the structure works like this: technological need is reported by a local government agency to a technology transfer office, if one exists within the state or jurisdiction. The second agency acts as a link to technological resources, including the National Bureau of Standards and other federal laboratories.

Of course, the concept of applying innovative technology originally developed for one purpose to the solution of other problems is very old. For example, early Romans constructed masonry aqueducts to bring water from outlying areas into their cities—and their baths. Later, when the Roman legions were occupying the English midlands, they used indoor plumbing along Hadrian's Wall, in concert with systems for heating the water. Needless to say, the local populace of this cold, damp region accepted the innovation with enthusiasm.

Within the United States, the first organized attempt at transferring technology from a federal agency to local users began with the Department of Agriculture's Cooperative Extension Service back in 1914. The linking agent (the extension service field agent) would talk with the local potential users (farmers) to find out what their problems were. These problems would then be referred to the resources (land grant colleges or the USDA), which would seek or develop a solution to feed back to the user through the linking agent. Soliciting problems in order to search for the solutions is called the "pull" concept of technology transfer.

Almost two decades ago, when the National Aeronautics and Space Administration (NASA) was created, a charge was contained in its establishing legislation requiring that the agency seek means of using the technology produced for advanced aero or space travel toward solving of problems outside of NASA. Here, NASA first developed technology for its very specialized purpose and then searched for additional uses for that technology. This is called the "push" concept of technology transfer.

Both approaches produce results. But experience and studies show that effective technology transfer between federal agencies and local governments generally involves the "pull" approach. It is then imperative that local and state governments identify their needs, define them as specifically as possible, then seek solutions. In spite of obvious benefits it has been and continues to be difficult to build this kind of philosophy and capacity within state and local governments.

However, there is a growing awareness by state and local officials of the potential for assistance from federal laboratories. In 1972, the Council of State Governments published a booklet entitled "Power to the States: Mobilizing Public Technology," which called for many federal facilities, including NBS, to get involved in solving state problems. In 1974, a study by the Federal Council for Science and Technology, prepared by the Committee on Federal Laboratories and chaired by the Director of NBS, called for renewed efforts by the federal laboratories to make their technology available to state and local governments.

Another indication of growing interest is the proliferation of science advisory positions created at city and state levels throughout the U.S. Individually and collectively, cities and states are creating specific positions for scientific or technically oriented individuals whose full time job is to look for new technologies to solve local problems. Organizations such as the California Innovation Group,

Wyckoff is liaison officer, state and local governmental affairs, NBS Program Office. Miller is technology transfer coordinator for the State of Oregon.

turn page

The aftermath of a bridge collapse near Coos Bay, Oregon. An infestation of marine borers in wooden pilings caused the collapse and sent state officials searching for nondestructive test methods.

New England Innovation Group, and the Pennsylvania Technical Assistance Program are attempting on a regional basis to assist local governments. In addition, states such as New York, Louisiana, and Oregon have science or technology transfer offices. And even individual cities such as Seattle, Washington, Scottsdale, Arizona, and Tacoma, Washington, have special science advisor positions—frequently located right in the principal city administrator's office.

But if there is new interest from potential users, there is a matching interest from the federal resources. As Secretary of Commerce Juanita Kreps recently pointed out to Commerce officials, "You will recall President Carter's statement during the campaign that the nation's number one economic problem is our cities. I am transmitting his March 21, 1977, memorandum to you as a reminder of his deep commitment to assisting the cities. There is a responsibility which will involve most of the principal units of the Department to a far greater extent than before."

An organized, although informal, attempt to provide federal technological assistance to cities and states started long before Carter's memorandum. Back in 1971, eleven Department of Defense labs joined together to do that very thing. Each lab appointed a technology transfer representative and pledged its cooperation in seeking urban uses of the technology originally created for military purposes. That was the forerunner of what is now a more than 100-member Federal Laboratory Consortium for Technology Transfer, which includes laboratories from such federal agencies as Commerce, Justice, Interior, ERDA, Agriculture, NASA, Transportation and Defense. NBS is an active participant in this consortium and regularly attends the biannual meetings.

In a typical case, a problem faced by a local or state agency is brought to the attention of that organization's technology transfer agent. The individual scans references, which may include private companies, universities, other local or state agencies, or federal labs. Assuming that the expertise lies in a federal organization, the local agent contacts that laboratory's technology transfer coordinator, who in turn seeks out the technical specialist most likely to have an answer. In many cases, the specialist can refer the inquiring agent to existing publications or deal directly with local or state employees. Whether the technology is ultimately

adopted usually depends on a blend of administrative, social, political, and economic factors. But at least the local officials have access to the best technical information against which they can balance the other factors.

NBS is in a particularly strong position to aid states and cities in addressing their technical problems, but like other federal laboratories, it has other major missions to pursue. As the country's national standards laboratory, it must provide the measurement standards for the nation and give technical assistance to other federal agencies. However, many of the 2,000 publications and 100 major technical meetings each year deal with problems of concern to states and cities. In addition, NBS often provides the technical backup for agencies whose principal "customers" are state and local governments. NBS will continue to seek greater use of its research at these levels, both independently as well as through the Federal Laboratory Consortium.

Transferring current technologies is only the beginning. There is a longer range potential for NBS in assisting state and local governments through the tailoring of in-house research and development programs so they can have direct payoff in solving real-world local problems. One recent occurrence illustrates how this can happen:

Early this year, a bridge near Coos Bay, Oregon, collapsed because the wooden piles, partly submerged in salt water, gave way to a heavy infestation of marine borers. The state's Department of Transportation wanted to test other similarly constructed bridges to determine their condition. But how?

An official from the Oregon State Technology Transfer Office called NBS. The Bureau could not furnish technology or equipment for nondestructively testing the structural soundness of submerged wooden piles, but the caller was referred to academic work that related to the problem. State officials continued to search, and they finally located a partial solution to their problems: They were able to hire a Canadian firm to test 700 highly suspect pilings with an ultrasonic technique. However, cost prohibits the use of this service on a routine basis, which is what Oregon really wants. Since the Canadian firm will not sell its equipment, the state is still without a satisfactory resolution.

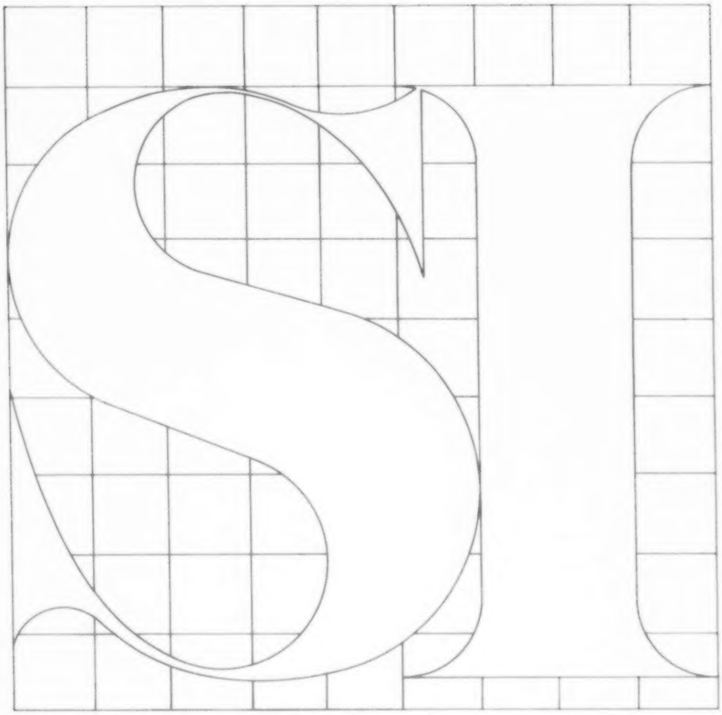
Following the Oregon incident, Missouri suffered a near disaster. A bridge collapsed within moments after a school bus filled with children had crossed in safety. The bridge was supported by submerged wooden pilings.

These events indicate that the need for testing these types of bridges is national in scope. In response, NBS has proposed a program to develop the appropriate technology. This is an isolated example of how local conditions can influence federal programs. But the larger goal is to find out about the long range technological needs of our cities and states and to determine how this data can be applied in formulating federal R&D projects. On the short term basis, inputs from individual local and state technology transfer offices are one source. Statements of technical need coming from nationwide organizations such as the 33-member city and county Urban Consortium for Technological Innovation and problems brought to the attention of the Federal Laboratory Consortium for Technology Transfer are two other ways. For the long term, however, a more systematic method must be devised which not only allows identification of problems on a national scale, but also provides for ranking the needs on a priority basis and assigning them to the best suited agency for solutions.

As successful as the united efforts have been to utilize federal technology to solve local and state difficulties, only the surface has been scratched. The local networks which have been established are principally experimental and serve only a small fraction of the cities. Only about half of the states have a science and technology advisory system in operation. And the federal Laboratory Consortium is a fully volunteer effort, each lab belonging because it believes in the concept. There is no national or even departmental policy requiring this federal cooperation with local and state governments.

But there is an opportunity and a challenge in these limitations. The opportunity is to make the best use of present federal R&D dollars in meeting the important existing needs of state and local governments. The challenge is to factor future national needs, according to priority, into the federal laboratories' R&D programs so that state and local governments can count on continuing federal support in solving some of their major technical problems. When that point is reached, the American taxpayer will be able to say the mission oriented federal R&D investment is also producing a handsome *local* return. □

The challenge is to factor state and local needs into federal R&D programs.



THE policy of the National Bureau of Standards is to encourage and lead in national use of the metric system, formally called the International System of Units (SI).[1] The NBS guidelines[2] are intended to aid and expedite the transition from the use of non-SI units to SI units in Bureau issuances, publications, and reports; they are to be implemented logically and equitably.

NBS practice is to use SI units in the publication of all descriptive and essential data (as defined below). SI units should be used by the NBS staff in both technical and non-technical publications and addresses. Exceptions are allowed when the intended audience would not comprehend such units. Until the national use of SI units prevails, exceptions to exclusive usage of SI units may be required in some NBS publications. The general rule is that exceptions must be determined by considering the audience for a given publication. If the readership

[1] The International System of Units (SI) was defined and given official status by the 11th General Conference on Weights and Measures, 1960. A complete listing of the SI units of weights and measures is presented in NBS Spec. Pub. 330, 1977 Edition. See also The Metric System: SI, page 14 and Appendix 1, page 16.

[2] These guidelines supersede LC1056 August 1975.

NBS GUIDELINES FOR THE USE OF THE METRIC

U. S. Department of Commerce/National Bureau of Standards

would be limited by the exclusive use of SI units, customary units may be added in parentheses for scientific and technical publications as well as in press releases and issuances to the general public. The emphasis should be not only on communicating the contents, but also on familiarizing readers with the metric system. In public and technical presentations the NBS staff should aid the audience in thinking metric; speakers should acquaint the audience with SI units if these units are not ordinarily used by the listeners. Exceptions to the exclusive use of SI units should be used to educate both technical and non-technical audiences in SI units and their use. An exception should not be invoked as a precedent for prolonging the use of non-SI units.

The transition period to the predominant national use of the metric system is not sharply defined. NBS leadership in this national adoption of SI units will be more effective if the transition within NBS is as complete and as rapid as possible. The staff is urged to remember this fact in the preparation of all NBS presentations and publications.

All numerical data, both descriptive and essential, are affected by this policy.

turn page

These guidelines are an important part of NBS commitment to the greatest practicable use of the International System of Units (SI) in all of our publications and also in all of our dealings and correspondence with the science and engineering communities and the public.

Two recent developments make necessary this revision of our guidelines for the use of SI: (1) the issuance of the Federal Register Notice of December 10, 1976, in accordance with the Metric Conversion Act of 1975 (PL 94–168), and (2) the issuance of the 1977 Edition of NBS Special Publication 330, The International System of Units (SI).

I urge all NBS staff to keep these guidelines handy and to use SI to the fullest possible extent. If you need further help or additional information on SI, call on your Editorial Review Board or on the Chief, Office of Technical Publications. They are available and anxious to assist in uniform and correct SI usage.

Ernest Ambler
Acting Director

SYSTEM

Descriptive data describe arrangements, environments, noncritical dimensions and shapes of apparatus, and similar measurements not affecting calculations or results. Such data should be expressed in SI units unless this makes the expression excessively complicated. For example, commercial gauge designations, commonly used items identified by nominal dimensions, or other commercial nomenclatures (such as drill sizes, or standards for weights and measures) expressed in customary units are acceptable.

Essential data express, precede, or interpret the quantitative results being reported. All such data should be expressed solely in SI units except in those fields where (a) the sole use of SI units would create a serious impediment to communications, or (b) SI units have not been specified. Exceptions may also occur when dealing with commercial devices, standards, or units having some legal definition, such as commercial weights and measures. Even in such instances, SI units should be used when practical and meaningful; for example, this may be done by adding non-SI units in parentheses after SI units. In tables, SI and customary units may be shown in parallel columns. In graphs, a secondary set of coordinate markings in non-SI units may also be included. The top and right-hand sides of a graph are often appropriate for this purpose.

The Metric System: SI

The SI is constructed from seven base units for independent quantities plus two supplementary units for plane angle and solid angle. (See Table 1.) Units for all other quantities are derived from these nine units. In Table 2 are listed 18 SI derived units with special names which are derived from the base and supplementary units in a coherent manner, which means in brief, that they are expressed as products and ratios of the nine base and supplementary units without numerical factors. All other SI derived units, such as those in tables 3 and 4, are similarly derived in a coherent manner from the 27 base, supplementary, and special-name SI units. For use with the SI units there is a set of 16 prefixes (see Table 5) to form multiples and submultiples of these units. For mass the prefixes are to be applied to the gram instead of to the SI unit, the kilogram.

The SI units together with the SI prefixes provide a logical and interconnected framework for measurements in science, industry, and commerce. Along with leading national, international, professional, and standardizing bodies, NBS encourages familiarity with, and diffusion of, SI units throughout all sectors of United States activities.

Fundamental Constants/Natural Units

In some cases quantities are commonly expressed in terms of fundamental constants of nature, and the use of these constants or "natural units" is acceptable. The author, however, should state clearly which natural units are being used; such broad terms as "atomic units" should be avoided when there is danger of confusion.

Typical examples of natural units are:

Unit	Symbol
elementary charge	e
electron mass	m_e
proton mass	m_p
Bohr radius	a_0
electron radius	r_e
Compton wavelength of electron	λ_C
Bohr magneton	μ_B
nuclear magneton	μ_N
speed of light	c
Planck constant	h

For additional examples, see "Fundamental Constants," *Dimensions/NBS*, Jan. 1974.

Units Acceptable for Use with SI

Certain units which are not part of the SI are used so widely that it is impractical to abandon them. The units that are accepted by NBS for continued use with the International System are listed in table 6. In those cases where their usage is already well established, the International Committee for Weights and Measures (CIPM) also has authorized, for a limited time, the use of the common units shown with an asterisk in table 7.

The short names for compound units (such as "coulomb" for "ampere second" and "pascal" for "newton per square meter") exist for convenience, and either form is correct (see table 2). For example, communication sometimes is facilitated if the author expresses magnetic flux in the compound term volt seconds (instead of using the synonym, webers) because of the descriptive value implicit in the compound phrase.

In some specialized fields (e.g., magnetism in material media), the appropriate quantities are still to be determined. Guidelines for these cases are flexible. Use of a table of conversion may be misleading, and it may even be preferred to compare different physical quantities in different systems of units.

Special Considerations

The kelvin (K) is the SI base unit of temperature; this unit is properly used for expressing temperature and temperature intervals. However, wide use is also made of the degree Celsius (°C) for expressing temperature and temperature intervals. The Celsius scale (formerly called centigrade) is related directly to thermodynamic temperature (kelvins) as follows:

The temperature interval one degree Celsius equals one kelvin exactly.

Celsius temperature (t) is related to thermodynamic temperature (T) by the equation:

$$t = T - T_0$$

where $T_0 = 273.15$ K by definition.

Logarithmic measures such as pH, dB, and Np are acceptable.

Words and symbols should not be mixed. If mathematical operations are indicated, for example, only symbols should be used. Any of the forms "joules per mole," "J/mol," "J•mol^{-1}" is considered good usage but the forms "joules/mole" and "joules•mol^{-1}" are not. See Appendix 2 for additional rules.

In all government printing of the National Bureau of Standards, the spellings "meter" and "liter" are to be used.

Over the years the term *weight* has been used to designate two quantities: *mass* and *force*. In conformity with the recommendation in the American National Standard for Metric Practice quoted in Appendix 3, the term *weight* will not be used in NBS publications except under circumstances in which its meaning is completely clear.

Implementation

NBS policy for the use of SI in its public documents is explicit. The staff is urged to aid in its implementation to the fullest degree practicable. Although the Bureau recognizes the necessity for a transitional period of education and adjustment, these guidelines are designed to place greater emphasis on the use of SI than before.

The provisions of this document are a part of the editorial approval criteria for all NBS writings undergoing review by division and Bureau editorial review boards. In addition, NBS staff members are urged to aid in the diffusion of the knowledge of SI units through all modes of communication including talks, correspondence, etc.

For additional information on the use of SI units, the NBS staff should obtain and use the following publications:

NBS SP330, 1977 Edition, "The International System of Units: SI"

ISO International Standard 1000 (1973 Edition) "SI Units and Recommendations for Use of Their Multiples"

American National Standard Z210.1-1976, American Standard for Metric Practice

Examples of conversion factors from non-SI units to SI are provided in table 7.

turn page

APPENDIX 1

Units and Conversion Factors

TABLE 1. **SI base and supplementary units**

	Quantity	Unit Name	Unit Symbol
SI base units	length	meter	m
	mass[1]	kilogram	kg
	time	second	s
	electric current	ampere	A
	thermodynamic temperature	kelvin	K
	amount of substance	mole	mol
	luminous intensity	candela	cd
SI supplementary units	plane angle	radian	rad
	solid angle	steradian	sr

[1] "Weight" is the commonly used term for "mass."

TABLE 2. **SI derived units with special names**

Quantity	SI Unit Name	Symbol	Expression in terms of other units	Expression in terms of SI base units
frequency	hertz	Hz		s^{-1}
force	newton	N		$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
quantity of electricity, electric charge	coulomb	C	$A \cdot s$	$s \cdot A$
electric potential, potential difference, electromotive force	volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
magnetic flux	weber	Wb	$V \cdot s$	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
Celsius temperature[(a)]	degree Celsius	°C		K
luminous flux	lumen	lm		$cd \cdot sr$[(b)]
illuminance	lux	lx	lm/m^2	$m^{-2} \cdot cd \cdot sr$[(b)]
activity (of a radionuclide)	becquerel	Bq		s^{-1}
absorbed dose, specific energy imparted, kerma, absorbed dose index	gray	Gy	J/kg	$m^2 \cdot s^{-2}$

[(a)] See Special Considerations, p. 15.
[(b)] In this expression the steradian (sr) is treated as a base unit.

TABLE 3. **Some SI derived units expressed in terms of base units**

Quantity	SI Unit	Unit Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2
wave number	1 per meter	m^{-1}
density, mass density	kilogram per cubic meter	kg/m^3
current density	ampere per square meter	A/m^2
magnetic field strength	ampere per meter	A/m
concentration (of amount of substance)	mole per cubic meter	mol/m^3
specific volume	cubic meter per kilogram	m^3/kg
luminance	candela per square meter	cd/m^2

TABLE 4. **Some SI derived units expressed by means of special names**

	SI Unit		
Quantity	Name	Symbol	Expression in terms of SI base units
dynamic viscosity	pascal second	Pa·s	$m^{-1}\cdot kg\cdot s^{-1}$
moment of force	newton meter	N·m	$m^2\cdot kg\cdot s^{-2}$
surface tension	newton per meter	N/m	$kg\cdot s^{-2}$
power density, heat flux density, irradiance	watt per square meter	W/m^2	$kg\cdot s^{-3}$
heat capacity, entropy	joule per kelvin	J/K	$m^2\cdot kg\cdot s^{-2}\cdot K^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg·K)	$m^2\cdot s^{-2}\cdot K^{-1}$
specific energy	joule per kilogram	J/kg	$m^2\cdot s^{-2}$
thermal conductivity	watt per meter kelvin	W/(m·K)	$m\cdot kg\cdot s^{-3}\cdot K^{-1}$
energy density	joule per cubic meter	J/m^3	$m^{-1}\cdot kg\cdot s^{-2}$
electric field strength	volt per meter	V/m	$m\cdot kg\cdot s^{-3}\cdot A^{-1}$
electric charge density	coulomb per cubic meter	C/m^3	$m^{-3}\cdot s\cdot A$
electric flux density	coulomb per square meter	C/m^2	$m^{-2}\cdot s\cdot A$
permittivity	farad per meter	F/m	$m^{-3}\cdot kg^{-1}\cdot s^4\cdot A^2$
permeability	henry per meter	H/m	$m\cdot kg\cdot s^{-2}\cdot A^{-2}$
molar energy	joule per mole	J/mol	$m^2\cdot kg\cdot s^{-2}\cdot mol^{-1}$
molar entropy, molar heat capacity	joule per mole kelvin	J/(mol·K)	$m^2\cdot kg\cdot s^{-2}\cdot K^{-1}\cdot mol^{-1}$
exposure (x and γ rays)	coulomb per kilogram	C/kg	$kg^{-1}\cdot s\cdot A$
absorbed dose rate	gray per second	Gy/s	$m^2\cdot s^{-3}$

turn page

TABLE 5. **SI prefixes**

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	μ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10^{1}	deka	da	10^{-18}	atto	a

TABLE 6. **Units in use with the International System**

Name	Symbol	Value in SI Unit
minute	min	1 min = 60 s
hour	h	1 h = 60 min = 3 600 s
day	d	1 d = 24 h = 86 400 s
degree	°	1° = (π/180) rad
minute	′	1′ = (1/60)° = (π/10 800) rad
second	″	1″ = (1/60)′ = (π/648 000) rad
liter	L*	1 L = 1 dm³ = 10^{-3} m³
metric ton	t	1 t = 10^{3} kg
hectare	ha	1 ha = 10^{4} m²

* The international symbol for liter is "l", which can be easily confused with the numeral "1". Accordingly, the symbol "L" is recommended for United States use.

TABLE 7. **Examples of conversion factors from non-SI units to SI**

Physical Quantity	Name of Unit	Symbol for Unit	Definition in SI Units
length	inch	in	2.54×10^{-2} m
length	nautical mile*	nmi	1852 m
length	angstrom*	Å	10^{-10} m
velocity	knot*	kn	(1852/3600) m/s
area	barn*	b	10^{-28} m²
acceleration	gal*	Gal	10^{-2} m/s²
mass	pound (avoirdupois)	lb	0.453 592 37 kg
force	kilogram-force	kgf	9.806 65 N
pressure	conventional millimeter of mercury	mmHg	$13.5951 \times 9.806\,65$ N·m^{-2}
pressure	atmosphere*	atm	101 325 N·m^{-2}
pressure	torr	Torr	(101 325/760) N·m^{-2}
pressure	bar*	bar	10^{5} Pa
stress	pound-force per sq. in	lbf/in²	6 894.757 Pa
energy	British thermal unit (Int. Table)	Btu	1055.056 J
energy	kilowatt hour	kWh	3.6×10^{6} J
energy	calorie (thermochemical)	cal	4.184 J
activity (of a radionuclide)	curie*	Ci	3.7×10^{10} Bq
exposure (x or γ rays)	röntgen*	R	2.58×10^{-4} C·kg^{-1}
absorbed dose	rad*	rd	1×10^{-2} Gy

* The CIPM has sanctioned the temporary use of these units.

APPENDIX 2

Writing Style Guides

1. CAPITALS

Units: When written in full, the names of all units start with a lowercase letter, except at the beginning of a sentence. Note that in degree Celsius the unit "degree" is lowercase but the modifier "Celsius" is capitalized. The "degree centigrade" is obsolete.

Symbols: Unit symbols are written with lowercase letters except that the first letter is uppercase when the name of the unit is derived from the name of a person and (2) the symbol for liter is capital L.

Prefixes: The symbols for numerical prefixes for exa(E), peta(P), tera(T), giga(G), and mega(M) are written with uppercase letters, all others with lowercase letters. All prefixes are written in lowercase letters when written out in full, except where the entire unit name is written in uppercase letters.

2. PLURALS

a. When written in full, the names of units are made plural when appropriate. Fractions both common and decimal are always singular.

b. Symbols for units are the same in singular and plural (no "*s*" is ever added to indicate a plural).

3. PERIODS

A period is NOT used after a symbol, except at the end of a sentence.

4. THE DECIMAL POINT

The dot is used as the decimal point and is placed on the line. In numbers less than one, a zero must be written before the decimal point.

5. GROUPING OF DIGITS

a. Separate digits into groups of three, counting from the decimal sign. The comma should not be used. Instead, a space is left to avoid confusion, since many countries use a comma for the decimal point.

b. In numbers of four digits, the space is not recommended, unless four-digit numbers are grouped in a column with numbers of five digits or more.

6. SPACING

a. In symbols or names for units having prefixes, *no* space is left between letters making up the symbol or the name.

b. When a symbol follows after a number to which it refers, a space must be left between the number and the symbol (except for degree, minute, and second of angle).

7. COMPOUND UNITS

In the symbol for a compound unit that is formed by the multiplication of two or more units, a centered dot is used. For example N•m.

In the name for such a unit, a space is recommended (or a hyphen is permissible) but never a centered dot. For example, newton meter or newton-meter.

APPENDIX 3

Quotation from the American National Standard for Metric Practice, Z210.1-1976

3.4.1.1 The principal departure of SI from the gravimetric system of metric engineering units is the use of explicitly distinct units for mass and force. In SI, the name kilogram is restricted to the unit of mass, and the kilogram-force (from which the suffix *force* was in practice often erroneously dropped) should not be used. In its place the SI unit of force, the newton, is used. Likewise, the newton rather than the kilogram-force is used to form derived units which include force, for example, pressure or stress ($N/m^2 = Pa$), energy ($N \cdot m = J$), and power ($N \cdot m/s = W$).

3.4.1.2 Considerable confusion exists in the use of the term *weight* as a quantity to mean either *force* or *mass*. In commercial and everyday use, the term *weight* nearly always means mass; thus, when one speaks of a person's weight, the quantity referred to is mass. This nontechnical use of the term weight in everyday life will probably persist. In science and technology, the term *weight of a body* has usually meant the force that, if applied to the body, would give it an acceleration equal to the local acceleration of free fall. The adjective "local" in the phrase "local acceleration of free fall" has usually meant a location on the surface of the earth; in this context the "local acceleration of free fall" has the symbol g (sometimes referred to as "acceleration of gravity") with observed values of g differing by over 0.5% at various points on the earth's surface. The use of *force of gravity* (mass times acceleration of gravity) instead of *weight* with this meaning is recommended. Because of the dual use of the term weight as a quantity, this term should be avoided in technical practice except under circumstances in which its meaning is completely clear. When the term is used, it is important to know whether mass or force is intended and to use SI units properly as described in 3.4.1.1, by using kilograms for mass or newtons for force □

ON LINE WITH INDUSTRY

INDUSTRY CALLS FOR MORE FEDERAL INITIATIVE IN SOLVING EMI PROBLEMS

by Michael Baum

The federal government should take stronger, more definite measures to identify and cope with basic aspects of the electromagnetic interference (EMI) problem. That was the message brought by auto industry representatives to a recent workshop on EMI sponsored by the National Bureau of Standards.

According to one speaker, John T. Auman, an executive engineer with the General Motors engineering staff, the federal government must undertake a program to study and characterize the electromagnetic environment in the United States before industry can design electronic systems that are effectively and efficiently shielded from EMI.

The government, Auman suggested, was in a better position than any private firm to gather data on the countless electromagnetic sources—both government and civilian—in the country.

Auman's position was echoed by Ford Motor Company engineers Robert Oswald and Fred Bauer, who noted that excessive and expensive safety factors had to be built into new automotive electronics designed by Ford because electromagnetic (EM) environment data were not available. Last February, Ford announced the introduction of two new electronic controls on some 1978 cars.

Bauer, who is also chairman of the Society of Automotive Engineers Radio Interference Committee, noted that EMI is a world-wide problem and urged greater Federal support for international standards to define EM environments.

Baum is a writer and public information specialist in the NBS Office of Information Activities.

The statements came as part of a two-day workshop held in July by NBS which brought together 150 government and industry representatives to trade ideas on the rapidly growing EMI problem. Thousands of new EMI sources are added to the environment daily in the form of industrial equipment, appliances, automobiles and radio transmitters. The radiation can interfere with such important systems as computer controls and electronic braking or ignition systems on trucks, buses and planes.

NBS research in EMI is directed toward developing techniques to measure the strength of interference fields over a wide range of frequency, time and amplitude, both near and far from EMI sources. The Bureau also develops methods such as the transverse electromagnetic (TEM) cell to measure interference fields caused by electric or electronic devices, as well as the effect of other fields on those devices.

Much discussion at the NBS workshop concerned the problem of trying to measure the EMI conditions under which people and devices would have to work. In one session Samuel E. Probst, deputy assistant director for frequency management in the White House Office of Telecommunications Policy, suggested that characterizing the EM environment in the country was already a bigger problem than even the Federal government could handle.

One small scale effort to characterize the EM environment was described by an engineer from the FDA's Bureau of Medical Devices, David Segerson. Segerson reported on a study of the EM environment in hospitals conducted for FDA by McDonnell Douglas as a basis for an EM standard for medical devices.

Even that limited attempt at studying "electromagnetic pollution" was criticized by the next two speakers, Dr. L. Leslie Hamilton of the Health Industries Manufacturers Association, and clinical engineer Samuel Polaniecki from Brooklyn's Downstate Medical Center.

Polaniecki said that the method of assessing the EM environment of hospitals was inadequate, that the hospitals surveyed were not—at least in EMI—typical of the nation's hospitals, that the study ignored possible biological effects of the fields about some medical equipment, and that the progressive redrafting of the standard in response to comments was making it weak and meaningless.

A broader program within the Environmental Protection Agency was described by David Janes, chief of the EM Radiation Analysis Branch, which is evaluating the EM environment in several U.S. cities. Measurements in the seven cities surveyed so far indicate that in the frequency range from 40 kHz to 900 MHz (low to ultra-high frequency) about 90 percent of the general population is exposed to EM radiation at power levels below 1 microwatt per square centimeter (which is the Soviet standard—significantly lower than the U.S. limit) and about 90 percent of the power levels measured were also lower than 1 $\mu W/cm^2$.

Janes also stated that the EPA may propose EM radiation guidelines for federal agencies for public comment by early 1979.

The workshop attendees also discussed EMI and its effect on consumer electronics—radios, television sets and the like. Industry representatives such as Chuck Lynk from Motorola, Inc. and the Electronic Industries Association as well as government speakers such as Carlos Roberts of the Federal Communications Commission Office of Plans and Policy, Frank Rose of the FCC's Chief Engineer's Office, and Dr. Charles Jackson of the House Communications Subcommittee expressed desires to avoid Federal regulations that would set interference rejection standards for consumer electronics. Most favored instead a "public education" program to make consumers aware of the value of television sets and other home entertainment electronic equipment with EMI filtering circuits.

Where can you find all the reference data you need?

Right in the Journal of Physical and Chemical Reference Data!

Now in its sixth year, this valuable publication has proved that it fills the important gaps for you in the literature of the physical sciences.

Published by the American Institute of Physics and the American Chemical Society for the National Bureau of Standards, this quarterly gives you quantitative numerical data, with recommended values and uncertainty limits chosen by experts in the field.

Critical commentary on methods of measurement and sources of error, as well as full references to the original literature, is an integral part of each of your four issues a year.

Can you afford to be without this prime source of reliable data on physical and chemical properties? To start receiving your copies, just fill in the order form and drop into the mail. If you do use a purchase order, please attach the printed form as this will help us to expedite your order.

Send for complete list of reprints!

Journal of Physical and Chemical Reference Data
American Chemical Society
1155 Sixteenth Street,N.W., Washington, D.C. 20036

Yes, I would like to receive the JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA at the one-year rate checked below:

Name ______________________

☐ Home
☐ Business

Street ______________________

City ______________ State ________ Zip ________

Bill me ☐ Bill company or school ☐ Payment enclosed ☐

	Members	Nonmembers
U.S., Canada, Mexico	☐ \$25.00	☐ \$90.00
Other Countries	☐ \$29.00	☐ \$94.00

Please Attach This Order Form To Purchase Order

STAFF REPORTS

CONVERSION OF U.S. CUSTOMARY UNITS OF LENGTH, AREA, AND VOLUME TO SI

The international foot is smaller by exactly two parts per million than the survey foot. The following article gives guidance for determining which of our customary units are based on the international foot and which on the survey foot, and it gives the appropriate conversion factors from customary to metric.

Louis E. Barbrow, Standards Application and Analysis Division, Room A165 Technology Building 301/921-2658 and Bruce B. Barrow, Defense Communications Agency, Reston, Va. 22090.

In 1866 the U.S. Congress made it lawful to use "the weights and measures of the metric system" and listed the relationship

1 meter = 39.37 inches

as establishing a suitable equivalent. In 1893 this equation, in the form

1 yard = 3600/3937 meter

was made the *definition* of the yard in the U.S., thus tying the U.S. units of length to the International Prototype Meter. The British, however continued with their own Imperial Standard Yard, and over the years the inevitable differences between the two systems became increasingly troublesome.

In 1959, therefore, the national standards laboratories of Australia, Canada, New Zealand, South Africa, the United Kingdom, and the United States agreed to base all their calibrations upon metric measurement standards. They further agreed upon a common yard, defined by

1 yard = 0.9144 meter

and designated as the International Yard. This is the yard that has been used in the U.S. since 1959. It is shorter than the earlier yard of 3600/3937 meter by exactly two parts per million. The difference is of practical concern only in very precise applications.

One such application is that of surveying and land measurement. In the original announcement (Federal Register of July 1, 1959) concerning a refinement of the value of the yard, a provision was made to retain the old value of the foot

1 foot = 1200/3937 meter

for the purposes of precise surveying, and to give this unit the name U.S. survey foot. It was originally contemplated that the survey foot would be superseded by the international foot after some years had passed, but later moves toward widespread adoption of the metric system in the U.S. make it desirable to retain the U.S. survey foot and its multiples in land measurement in this country until such measurements are converted to the metric system.

In the ordinary applications of commerce, in science, and in other fields of technology, the international foot and its multiples are used in the United States.

The difference between the two feet is of concern only in precise measurements, as has been noted. Possible confusion is also reduced by the fact that only a few units are used in both surveying and ordinary commerce—the yard, for example, is not used in surveying, and the rod is not used in commerce.

The table below shows the two sets of U.S. customary units that are currently legal and in use. Units of length based on the international foot are shorter by exactly two parts per million than corresponding units based on the U.S. survey foot. Therefore units of area based on the international foot are very nearly four parts per million smaller, and units of volume based on the international foot are very nearly six parts per million smaller.

In the table below all of the defining relationships (first column) are exact. Conversion factors in the second and third columns that are exact are indicated by an asterisk (*).

U.S. CUSTOMARY UNITS OF LENGTH, AREA, AND VOLUME

	Defining Relationships	U.S. and International Units Used in Commerce (based on international foot)	Units Used in U.S. Mapping and Land Measurement (based on U.S. survey foot)
Length	inch 1 inch = 1/12 foot	1 in = 25.4 mm (*)	
	foot	1 international foot = 0.3048 meter (*)	1 U.S. survey foot = 1200/3937 meter (*)
	yard 1 yard = 3 feet	1 yard = 0.9144 m (*)	
	fathom 1 fathom = 6 feet		1 U.S. fathom = 7200/3937 m (*)
	rod 1 rod = 16.5 feet		1 U.S. rod = 19 800/3937 m (*)
	chain (Gunter's) 1 chain = 66 feet		1 U.S. Chain = 79 200/3937 m (*)
	statute mile 1 statute mile = 5280 ft	1 international statute mile = 1609.344 m (*) (Note 1)	1 U.S. statute mile = 1609.347 m
	nautical mile 1 international nautical mile = 1852 m (Note 2)		

Note 1: The international statute mile is not used in the U.S., but it is used in other English-speaking countries.

Note 2: The international nautical mile was adopted in the U.S. in 1954.

U.S. CUSTOMARY UNITS OF LENGTH, AREA, AND VOLUME

	Defining Relationships	U.S. and International Units Used in Commerce (based on international foot)	Units Used in U.S. Mapping and Land Measurement (based on U.S. survey foot)
Area	square inch 1 in^2 = (1/144) ft^2	1 in^2 = 6.4516 cm^2 (*)	
	square foot	1 international foot squared = 0.092 903 04 m^2 (*)	1 U.S. survey foot squared = 0.092 903 41 m^2
	square yd 1 yd^2 = 9 ft^2	1 yd^2 = 0.836 127 36 m^2 (*)	
	acre 1 acre = 43 560 ft^2		1 U.S. acre = 4046.873 m^2
	section 1 section = 640 acres = 1 statute mile squared		1 U.S. section = 2.589 998 km^2
	township 1 township = 36 sections		1 U.S. township = 93.239 94 km^2
Volume	cubic inch 1 in^3 = (1/1728) ft^3	1 in^3 = 16.387 064 cm^3 (*)	
	cubic foot	1 international foot cubed = 0.028 316 85 m^3	
	cubic yard 1 yd^3 = 27 ft^3	1 yd^3 = 0.764 554 9 m^3	
	acre foot 1 acre foot = 43 560 ft^3		1 U.S. acre foot = 1233.489 m^3
	gallon 1 gallon (U.S.) = 231 in^3	1 gallon (U.S.) = 3.785 412 L	
	bushel 1 bushel (U.S.) = 2150.42 in^3	1 bushel (U.S.) = 35.239 07 L	

DATA CENTER INVESTIGATES OXYGEN AND SULFUR IN COPPER

A critical review of the transport behavior of oxygen and sulphur in copper and copper alloys has been completed.

Sherman Fivozinsky, Office of Standard Reference Data, A535 Administration, 301/921-2104.

During refining, fabrication, and use of copper and its alloys, there is ample opportunity for oxygen and sulfur to diffuse into the metal and change many of its physical properties. For this reason a critical review of the transport behavior of oxygen and sulfur was undertaken by the NBS Diffusion in Metals Data Center. Over 500 references from the world's scientific and engineering literature were reviewed and critically evaluated. Papers related to corrosion phenomena (oxidation and sulfidation) in copper and copper alloys at elevated temperatures, and hydrogen embrittlement were also included. The work involved many alloys of commercial interest as well as laboratory prepared alloys.

Both the electrical and thermal conductivities of copper and its alloys are changed by an oxygen impurity. Well established transport properties are therefore important to provide industrial processes which can produce high purity, high conductivity, oxygen free copper. Sulfur impurities are often introduced to optimize the machining properties of the metal. However, if excess amounts of sulfur are contained in the metal, a deleterious eutectic forms in grain boundaries. In addition, embrittlement can occur when hydrogen diffusing into copper reacts with the oxygen impurity forming water vapor at high pressure, with the consequence of local destruction of the metal's microstructure.

This critical evaluation will be published in the Journal of Physical and Chemical Reference Data as part of a forthcoming series on diffusion in copper and its alloys.

turn page

CRYOCOOLER INVENTION DISCLOSED

Small superconducting devices are currently operated almost universally in liquid-helium cryostats. Because of the increasing number of applications of SQUID's (superconducting quantum interfering devices), a study was begun of the possibilities of maintaining the required operating temperatures with a low-power closed-cycle cryogenic refrigerator. The cost of helium will increase as the supply diminishes, whereas the cost of such a closed-cycle refrigerator should decrease substantially if they can be produced in sufficient quantities to replace present liquid-helium cryostats.

James E. Zimmerman, Cryogenics Division, Boulder, Colorado, Room 2003B, 303/499-1000, ext. 3901.

My invention is a low-temperature refrigerator, or "cryocooler," designed specifically for cooling a SQUID. The SQUID is currently the preeminent superconducting device. Many hundreds are now in use in a variety of applications, all in liquid-helium cryostats.

Very low temperatures (13 to 8.5 K) can be achieved by the simple multistate mechanism of my machine. The machine is unique in that:

1. It uses 10 to 100 times lower input power than any previous experimental or commercial machine built or thought possible;
2. It achieves several orders of magnitude lower magnetic and mechanical noise (interference) in the superconducting device than previous experimental or commercial machines due to its construction and low operating speed and power and the materials chosen.
3. It utilizes the properties of materials to achieve the very close tolerances required in a machine operating on such low input power, and
4. It uses "exotic" materials—that is, materials not previously considered for moving and stationary parts of a reciprocating refrigerator.

These four features have certain individual merits. The success of my invention depends on each of these individually and on their merit in combination, which is greater than the sum of the individual merits.

Features 1, 2 and 4 are self-explanatory. The third characteristic makes possible the very small clearance between the machine's displacer and displacer cylinder (0.02 to 0.005 mm) over the total length. This would be difficult and expensive to achieve by conventional methods. What I did was to make the displacer of nylon and the cylinder of epoxy-glass composite. The nylon was machined for a tight fit (no clearance) at room temperature. Nylon shrinks a little more than the epoxy-glass composite. A nearly optimum clearance is established by this inherent property of the materials as the machine cools down to the operating temperature.

Another technical problem is that commercial rod and tubing is seldom precisely straight. With small clearances this would lead to friction between the displacer and cylinder because of different bends in the two meters. I solved this by forcing the displacer into the cylinder at room temperature (no clearance) and heating the assembly up to 80 or 90 °C for a few minutes. This procedure anneals and relaxes the nylon into precise conformation with the cylinder, so when cooled to room temperature, both members have precisely the same slight bends (if any) in the same direction. Thus, the properties of the materials are used in a unique way to solve simply, what would otherwise be a very exacting and quite expensive job of shaping the displacer to the cylinder.

The cryocooler is a split Stirling machine with a multi-stepped displacer and gap regenerator. The gap regenerator Stirling machine was invented in 1816 and used for refrigeration about 1860. The word "split" means simply that the working cylinder (which contains a piston) and the displacer cylinder are physically separate. They are connected by a tube so the gas pressure equalizes in both at all times. The multi-stepped displacer is an ingenious modification which makes the machine multistage and capable of achieving very low temperatures. This mechanical modification was invented by Pokker and Kohler about 1950.

The operation and some characteristics of the cryocooler are summarized in two recent papers. When the papers were written, the achieved temperature of the cryocooler was 13 K. (See references.) Recently I refined the machine and it now maintains a temperature of 8.5 K.

During the spring and summer of 1977, a pure niobium SQUID was operated in the machine. The superconducting transition temperature of niobium is around 9 K. The operation of the SQUID confirmed that the interference (at the SQUID generated) by my machine is indeed very much smaller than that by any commercially-available machine. The achieved interference level is in the order of 10^{-10} tesla. Additional interference reductions are expected by other changes in the machine's mounting geometry and supports.

I have also claimed that my cryocooler is a uniquely simple mechanism. All materials are readily available. Thus, superconductivity and other low temperature phenomena need no longer be a monopoly of a few specialists with easy access to liquid helium.

References

1. "Possible Cryocoolers for SQUID Magnetometers," Superconducting Quantum Interference Devices and Their Applications, Walter de Gruyter and Co., Berlin 1977.
2. "Refrigeration for Small Superconducting Devices," Deutsche Kaltetechnische Verein, Munich 1976 (to be published in German and English).

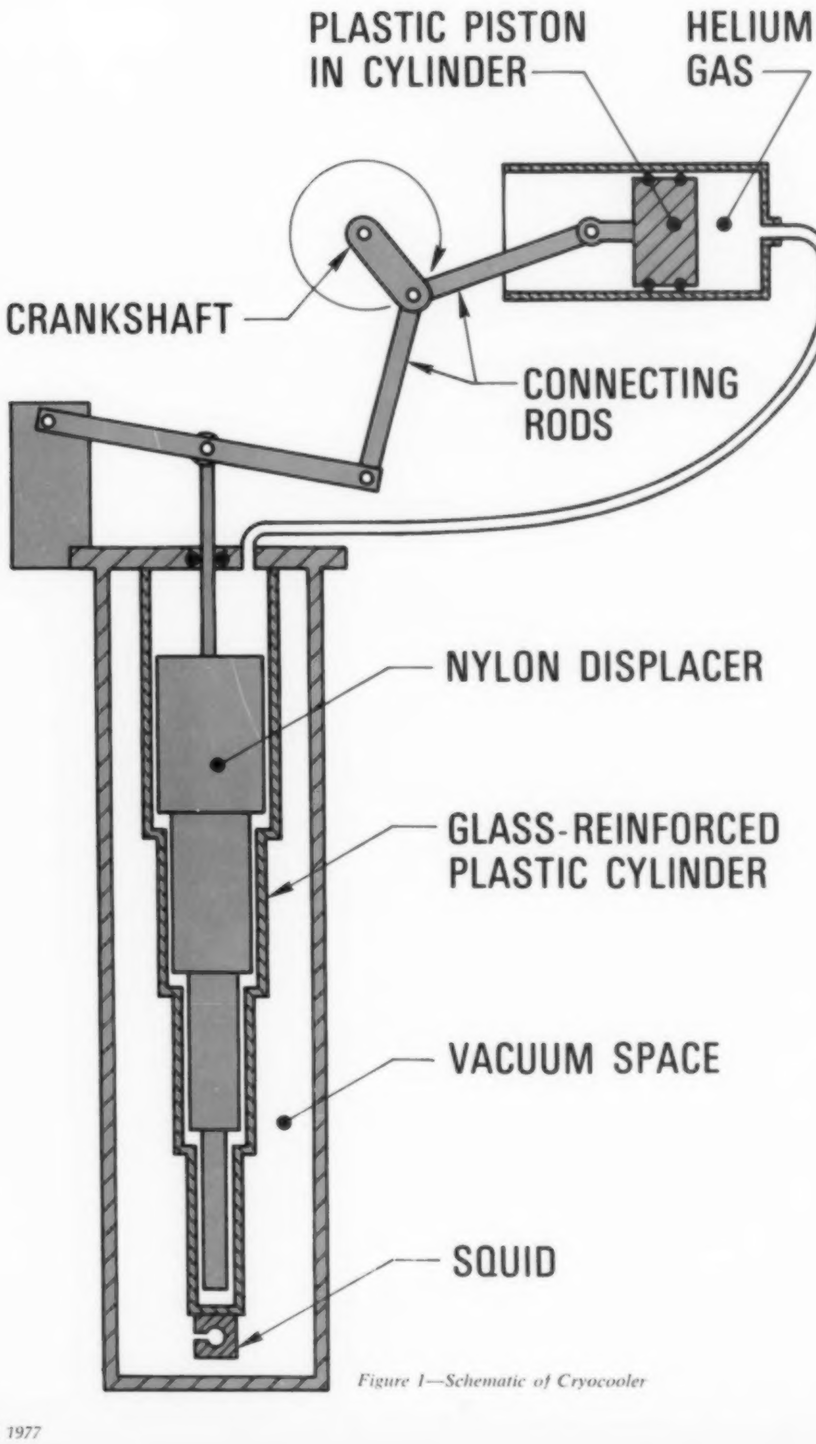


Figure 1—Schematic of Cryocooler

turn page

REFERENCE MATERIALS AVAILABLE FOR CALIBRATING LEAD DETECTION INSTRUMENTS

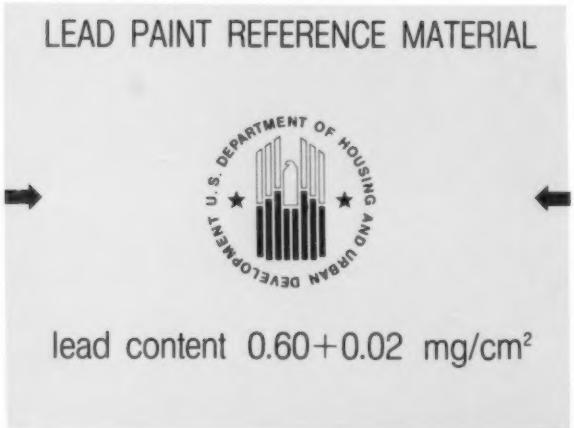
Health and housing inspectors will now be able to calibrate lead detection instruments using a simple method developed by the National Bureau of Standards, working for the Department of Housing and Urban Development (HUD).

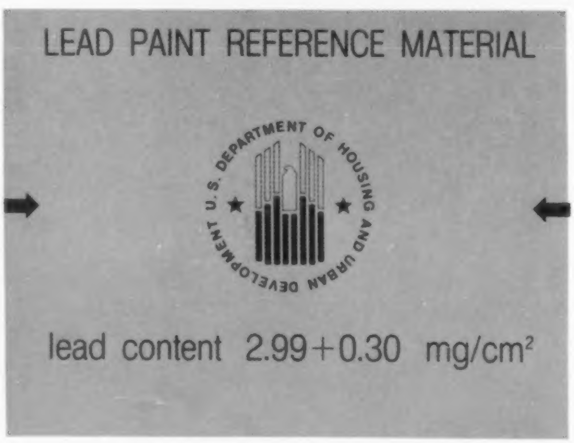
A. Philip Cramp and Harvey W. Berger, Office of Housing and Building Technology, Room B252 Physics Building, 301/921-3281.

Lead detection instruments, known as portable x-ray fluorescent analyzers, are used to determine the lead content in walls, woodwork, and other painted surfaces of homes. The finding of a high lead content may indicate a health hazard to children who would ingest lead paint chips. If a hazard is identified, health officials recommend eliminating the hazard by removing it or by covering the lead paint surfaces.

If a portable detection instrument is not calibrated properly, it may give a false reading—causing an area to be stripped unnecessarily or allowing lead-contaminated paint to remain on housing surfaces.

To overcome this problem, NBS has produced lead paint reference materials for distribution by HUD and use by local inspectors. The materials were manufactured according to NBS specifications by the Munsell Color Company, Baltimore, Md., which is widely known for its preparation of uniform and reproducible color standards for government and the paint industry. The reference materials are color-coded to make each one easily distinguishable from the others.





NBS was asked to undertake this assignment by HUD because of the Bureau's expertise in developing standard reference materials and because of the Bureau's long-standing commitment to provide technical assistance to the Department.

The reference materials are in the form of 7.5-cm by 10-cm sheets of coated paper with adhesive backing. Three reference series contain 3.0, 1.5 and 0.6 milligrams of lead per square centimeter (mg/cm^2), respectively. Each sheet is imprinted with the lead content and has alignment marks to assist the inspector in centering his analyzer over the panel in a correct manner. The panel may be used as is or may be adhered permanently to a lead-free surface such as an unpainted block of wood or gypsum wallboard.

Persons wishing to obtain more information about the lead paint reference materials should contact the Lead Based Paint Poisoning Prevention Research Program at the Department of Housing and Urban Development, Washington, D.C. 20410.

NBS UNDERTAKES DATA WORK FOR ENERGY PROBLEMS

Data needed for designing coal liquefaction and gasification plants are being compiled and evaluated.

Howard J. White, Jr., Office of Standard Reference Data, A523 Administration Building, 301/921-2581.

The National Bureau of Standards' Office of Standard Reference Data (OSRD) has signed a research aagreement with the Institute for Gas Technology (IGT) under which OSRD will supply compiled and evaluated data on the thermophysical and thermodynamic properties of pure compounds found in coal-derived liquids. The work will be carried out by the Thermodynamic Center of Texas A & M University, one of the data centers in the National Standard Reference Data System.

These data on the physical properties of components will be part of a handbook of data on coal-conversion processes being prepared by IGT under the sponsorship of the Energy Research and Development Administration. The handbook is intended to provide physical, chemical, and engineering data needed by engineers for the design of various types of coal-gasification and coal-liquefaction plants. It is anticipated that, as the work progresses, OSRD will be called upon to prepare compilations of data on other types of physical and chemical properties with the assistance of other data centers in the National Standard Reference Data System.

EXCHANGE PROGRAM FOR STATE AND LOCAL GOVERNMENT EMPLOYEES

The National Bureau of Standards has established a new program that allows employees of State and local governments to work at NBS on projects of mutual interest.

Technically qualified employees of state and local governments and the academic and public interest groups that serve them are eligible for the new program which is based on the Intergovernmental Personnel Act of 1970. Participants would work for as little as one month or as long as two years at NBS laboratories in Gaithersburg, Md., or Boulder, Colo.

The program is intended to provide new opportunities for intergovernmental cooperation in solving measurement and standards problems. Areas of mutual interest might include productivity, energy conservation. environmental cleanup, fire prevention and control, and health and safety.

Funding arrangements are flexible and will be arranged on a case-by-case basis. Participants will have access to NBS' extensive scientific and technical facilities and will be able to work with NBS staff in problem solving.

Further information may be obtained by writing to the Liaison Officer, State and Local Government Affairs, Room A402, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

MATERIALS FOR COAL CONVERSION AND UTILIZATION CONFERENCE

The First International Conference on Materials for Coal Conversion and Utilization is to be held October 11-13, 1977 at the National Bureau of Standards, Gaithersburg, MD. The Conference will provide a forum for discussion of ongoing materials research and development in coal conversion and utilization. As such, it is a continuation of the ERDA-EPRI-AGA Conference on Materials for Coal Conversion and Utilization held at the ERDA office in Germantown September 30-October 1, 1976. Researchers from private industry, universities, and the National Laboratories will present their work in the applied materials research area. Speakers will be drawn from ERDA, EPRI and AGA Contractors. The scope of the meeting has been broadened by the inclusion of a session on materials for MHD and an international section.

A brief outline of the Conference is as follows:

General Session

- Overview of process developments.
- Overview of materials research in USA, W. Germany, Netherlands and Great Britain.
- Materials experience in pilot plants.

Current Sessions

- Metals for coal conversion, high and low temperature applications, sulfidation, hot corrosion, aqueous corrosion, pressure vessel steels.
- Ceramics for coal conversion, gaseous and slag corrosion, erosion, design.
- Materials for direct utilization, hot corrosion, ceramic heat exchangers.
- Materials for MHD, airpreheaters, channel materials, combustor materials.

A total of about 15 general and introductory papers and about 50 technical papers will be presented. The conference will cover most applied materials research projects in this new field.

Registration

A registration fee will be charged to all attendees to help defray the total cost of conducting the Conference and its direct activities.

For further information contact: Ronald B. Johnson, B348 Materials Building, NBS, 301/921-3485.

WINTER SIMULATION CONFERENCE

Computer simulation as a professional field of specialization and as a versatile resource for many different kinds of users will be comprehensively explored at the 1977 Winter Simulation Conference, to be held on December 5-7 at the National Bureau of Standards in Gaithersburg, MD.

The program will feature tutorials in simulation for novices, managers, industry executives, and developers of financial models. Applications in areas such as energy, criminal justice, behavioral science, agriculture, environment, and health care will be aired at numerous sessions of the three-day conference.

Published proceedings of this year's winter conference will, in addition, incorporate papers prepared for the Symposium on the Simulation of Computer Systems (SSCS), which is not formally convening its originally scheduled August 9-11 sessions.

Six leading organizations sharing an interest in computer simulation are cosponsors, with NBS, of the winter conference. They are: the Operations Research Society of America, the Association for Computing Machinery's Special Interest Group on Simulation, the Institute of Electrical and Electronics Engineers, the American Institute of Industrial Engineers, the Society for Computer Simulation, and the Institute of Management Sciences.

The current conference is the ninth in a series that began in 1967. Inquiries concerning registration for the conference should be addressed to: Mr. Claude Delfosse, CACI, Inc., 1815 North Fort Myer Drive, Arlington, VA 22209, Phone: 703/841-7800.

CONFERENCE CALENDAR

October 11-13

MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS, Energy Research and Development Administration, Electric Power Research Institute; contact: S. J. Schneider, B303, Materials Building, 301/921-2893.

October 11-14

COMPUTER PERFORMANCE EVALUATION USERS GROUP, 13TH MEETING, New Orleans, LA., sponsored by NBS; contact: Dennis Conti, A248 Technology Building, 301/921-3861.

October 12-14

WORKSHOP ON LOW TEMPERATURE MATERIALS FOR MAGNETIC FUSION DEVICES, Vail, Colo.; sponsored by NBS and Energy Research and Development Administration; contact: Fred Ackett, NBS 303/499-1000, ext. 3785.

October 17-19

TIME AND FREQUENCY CALIBRATION: METHODS AND RESOURCES, NBS, Boulder, Colo.; sponsored by NBS; contact: Roger Beehler, NBS, Boulder, Colo., 303/499-1000, ext. 3281.

October 19-20

RELIABILITY TECHNOLOGY FOR CARDIAC PACEMAKERS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry A. Schafft, A327 Technology Building, 301/921-3625.

November 1-3

MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry C. Burnett, B260 Materials Building, 301/921-2818.

November 13-17

WORKSHOP ON RAPID SOLIDIFICATION TECHNOLOGY, Sheraton-Reston, VA; sponsored by NBS and ARPA; con-

tact: Dr. Arthur Ruff, B264 Materials Building, 301/921-2811.

*November 29-30
MEASUREMENTS AND STANDARDS FOR RECYCLED OIL; NBS, Gaithersburg, MD; sponsored by NBS; contact: Donald A. Becker, B50 Physics Building, 301/921-3827.

*November 30-December 2
ACCURATE LINE-WIDTH MEASUREMENT ON INTEGRATED CIRCUIT PHOTOMASKS, NBS, Gaithersburg, MD; sponsored by NBS; contact: John Jerke, A123 Metrology Building, 301/921-2185.

December 5-7
WINTER SIMULATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, and the Society for Computer Simulation; contact: Paul F. Roth, B250 Technology Building, 301/921-2545.

*December 12-13
WORKSHOP ON HIGH TEMPERATURE CHEMICAL KINETICS, NBS, Gaithersburg, MD; sponsored by NBS; contact: David Garvin, B152 Chemistry Building, 301/921-2771.

December 15
COMPUTER NETWORKING SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and the IEEE Technical Committee on Computer Communications; contact: Helen M. Wood B212 Technology Building 301/921-2601.

1978

March 13-15
CONSTRUCTION DOCUMENTATION CONFERENCE; NBS, Gaithersburg, MD; sponsored by NBS, the Construction Specifications Institute, and the Guide Specification Committee of the Federal Construction Council; contact: Roger Rensburger, A151 Technology Building, 301/921-3126.

March 22-24
28TH IEEE VEHICULAR TECHNOLOGY CONFERENCE; Denver, Colo; sponsored by NBS and IEEE; contact: Hohn Shafer, NBS, Boulder, Colo., 303/499-1000, ext. 3185.

April 10-13
TRACE ORGANIC ANALYSIS; A NEW FRONTIER IN ANALYTICAL CHEMISTRY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry S. Hertz, A105 Chemistry Building, 301/921-2153.

April 17-20
ACOUSTIC EMISSION WORKING GROUP MEETING, NBS, Gaithersburg, MD; sponsored by NBS; contact: John A. Simmons, B118 Materials Building, 301/921-3355.

April 23-26
AMERICAN NUCLEAR SOCIETY TOPICAL CONFERENCE ON COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA RAY SPECTROSCOPY: Mayaguez, Puerto Rico; sponsored by NBS, American Chemical Society, American Nuclear Society, Energy Research and Development Administration, U. of Puerto Rico, Puerto Rico Nuclear Center; contact: B. S. Carpenter, B108 Reactor Building, 301/921-2167.

May 8-10
SYMPOSIUM ON REAL-TIME RADIOGRAPHIC IMAGING, NBS, Gaithersburg, MD; sponsored by NBS and the American Society for Testing and Materials; contact: Donald A. Garrett, A106 Reactor Building, 301/921-3634.

*June 19-21
GAS KINETICS CONFERENCE, NBS, Gaithersburg, MD.; sponsored by NBS and the Committee on Chemical Kinetics, NBS/NRC; contact: David Garvin, B152 Chemistry Building, 301/921-2771.

June 26-29
CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, Ottawa, Ontario, Canada; sponsored by Institute of Electrical and Electronics Engineers, U.S. National Committee-International Union of Radio Science, and NBS; contact: Dee Belsher, NBS, Boulder, Colo., 303/499-1000, ext. 3981.

July 17-20
AMERICAN ASSOCIATION FOR CRYSTAL GROWTH IV, NBS, Gaithersburg, MD.; sponsored by NBS and AACG; contact: Dr. Robert Parker, B164 Materials Building, 301/921-2961.

---

*New Listings

PUBLICATIONS

NEW EDITION OF OFFICIAL PUBLICATION ON THE INTERNATIONAL SYSTEM OF UNITS (SI)

The International System of Units (SI), Nat. Bur. Stand. (U.S.), Spec. Publ. 330, 46 pages (Aug. 1977), Stock No. 003-003-01784-1, $1.60.

by Louis Barbrow

National Bureau of Standards Publication 330, "The International Systems of Units (SI)," is the U.S. English translation approved by the International Bureau of Weights and Measures of its publication, in French, which is recognized as the most authoritative international document on the modernized metric system, commonly referred to as SI. The first edition of SP330 was published in 1971 with a second edition first published in 1972 and then somewhat revised in 1974. The third edition of SP330 is now in print.

The principal differences between the 1977 edition and the previous 1974 edition of SP330 are (1) the addition of two prefixes, peta (P) for 10^{15} and exa (E) for 10^{18}; (2) the addition of three SI derived units with special names (bringing the total to 18): the becquerel (Bq) for activity of a radionuclide, the gray (Gy) for absorbed dose and similar quantities, and the degree Celsius (°C) for Celsius temperature; (3) recognition of U.S. use (a) of the capital "L" instead of the lowercase "l" as the symbol for liter, (b) of the hectare as a unit of land and water area in use with the International System of Units, and (c) of "weight" as the commonly used term for "mass;" and (4) the use of the spellings "meter" and "liter," instead of "metre" and "litre," to conform to the usage in the Federal Register notice of December 10, 1976, *The Metric System, Interpretation and Modification of the International System of Units for the United States.*

Additionally, the 1977 edition includes an index. A larger, 7⅞- by 10¼-inch (20-x 26-cm) size permits a format change that provides column titles, which guide readers to the topics in which they may be interested.

Barbrow is coordinator of metric activities at NBS.

ORTHOPAEDIC IMPLANTS PUBLICATION

Retrieval and Analysis of Orthopaedic Implants, Weinstein, A., Horowitz, E., and Ruff, A. W., Nat. Bur. Stand. (U.S.), Spec. Publ. 472, 130 pages (Apr. 1977) Stock No. 003–003–01767–1, $2.

Use of a standard uniform protocol for retrieving and analyzing orthopaedic implants for their performance is one of the recommendations contained in a new publication from the National Bureau of Standards.

Titled, *Retrieval and Analysis of Orthopaedic Implants,* the publication contains recommendations developed by attendees at a symposium held in March 1976. The symposium brought together manufacturers, orthopaedic surgeons, engineers, government officials, and others interested in enhancing the performance of orthopaedic implants. As a direct outgrowth of the Symposium, the American Society for Testing and Materials (ASTM) Committee F-4 on Medical and Surgical Materials and Devices is currently working on development of such a protocol for removing, storing, and studying orthopaedic implants.

The reliability and durability of many synthetic materials implanted in the human body are a matter of increasing concern as the trend today is toward implantation in younger and more active patients. In the United States alone, more than 1 million orthopaedic devices are implanted into humans each year. Information on the performance of these devices can be gained by analyzing retrieved implants, and through this analysis, performance criteria and specifications for implants can be further improved.

In addition to recommendations for obtaining performance information, the proceedings also contain state-of-the-art information on the characteristics and performance of synthetic orthopaedic implants. Included are presentations on failure modes in orthopaedic implants, performance feedback via retrieval and analysis, tissue reactions to biomaterials, legal aspects of device retrieval, and a panel discussions on implant retrieval. The transcript of a one-day workshop on the national need regarding orthopaedic implants is included.

The symposium was cosponsored by NBS, ASTM, the Food and Drug Administration, the American Academy of Orthopaedic Surgeons, the Orthopaedic Surgical Manufacturers Association, and the Society for Biomaterials. NBS Special Publication 472, *Retrieval and Analysis of Orthopaedic Implants* was edited by symposium chairman Dr. Allan Weinstein of Tulane University and cochairman Dr. Emanuel Horowitz and Dr. A. W. Ruff of the NBS Institute for Materials Research.

OF THE NATIONAL BUREAU OF STANDARDS

Building Technology

Fenves, S. J., and Wright, R. N. *The Representation and Use of Design Specifications*, Nat. Bur. Stand. (U.S.), Tech. Note 940, 51 pages (June 1977) Stock No. 003-003-01790-6, $2.

Lew, H. S., Ed., *Wind and Seismic Effects. Proceedings of the Eighth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, May 18-21, 1976, National Bureau of Standards, Gaithersburg, MD.*, Nat. Bur. Stand. (U.S.), Spec. Publ. 477, 826 pages (May 1977) Stock No. 003-003-01772-8, $6.25.

Computer Science and Technology

Fong, E., *Computer Science and Technology: A Data Base Management Approach to Privacy Act Compliance*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-10, 34 pages (June 1977) Stock No. 003-003-01787-6, $1.40.

Gray, M. M., *Computer Science and Technology: Computers in the Federal Government: A Compilation of Statistics*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-7, 41 pages (June 1977) Stock No. 003-003-01780-9, $1.60.

Health and Safety

Collard, J. J., *Report on an Investigation of the High Speed Hazards of Steel Belted Radial Tires on Police Cars*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-18, 40 pages (June 1977) Stock No. 003-003-01786-8, $1.60.

Steinberg, H., *The Hazard of Benzidine to Criminal Justice Personnel*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-21, 16 pages (May 1977) Stock No. 003-003-01777-9, $1.

Stroik, J. S. *Terms and Definitions for Door and Window Security*, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-22, 16 pages (May 1977) Stock No. 003-003-01774-4, $1.

Tascher, J. M., *Toy Safety, (ANSI/VPS PS 72-76)*, Nat. Bur. Stand. (U.S.), Prod. Stand. 72-76, 30 pages (Jan. 1977) Stock No. 003-003-01702-7, $1.40.

Electronic Technology

Devaney, J., Leedy, K. O., and Keery, W. J., *Semiconductor Measurement Technology: Notes On SEM Examination of Microelectronic Devices*, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-35, 34 pages (Apr. 1977) Stock No. 000-003-01755-8, $1.10.

Engineering Product and Information Standards

Conti, D. M., Guideline on Computer Performance Management: An Introduction, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 49, 14 pages (1977).

Cooke, P. W., Ed., Research and Innovation in the Building Regulatory Process. Proceedings of the First NBS/NCSBCS Joint Conference held in Providence, RI, on Sept. 21-22, 1976, in Conjunction with the Ninth Annual Meeting of the National Conference of States on Building Codes and Standards (NCSBCS), Inc., Nat. Bur. Stand. (U.S.), Spec. Publ. 473, 504 pages (June 1977) Stock No. 003-003-01775-2, $6.

Slattery, W. J., Tabulation of Voluntary Standards for Consumer Products, Nat. Bur. Stand. (U.S.), Tech. Note 948, 187 pages (June 1977) Stock No. 003-003-01779-5, $3.25.

General Theoretical Chemistry and Physics

Danos, M., and Gillet, V., Relativistic Many-Body Bound Systems: Electromagnetic Properties, Nat. Bur. Stand. (U.S.), Monogr. 147, Suppl. 1, 52 pages (Apr. 1977) SD Catalog No. C13.44:147/Suppl. 1, $1.10.

Instrumentation and Experimental Methods

Mazur, J., A FORTRAN Program for Demeasuring Small-Angle X-Ray Scattering Curves, Nat. Bur. Stand. (U.S.), Tech. Note 936, 83 pages (Apr. 1977) Stock No. 003-003-01752-3, $1.45.

Measurement Science and Technology Policy and State-of-the-art Surveys

Teller, E., Ramsey, N., Kaker, W. O., Eyring, H., Birkoff, G., Perlis, A., Seamans, R. C., Jr., Ramo, S., and Thomson, R. M., Ed., Science and Technology in America—Assessment, Nat. Bur. Stand. (U.S.), Spec. Publ. 465, 165 pages (June 1977) Stock No. 003-003-01728-1, $2.50.

Metrology: Physical Measurements

Mangum, B. W., and Thornton, D. D., Eds., The Gallium Melting-Point Standard, Nat. Bur. Stand. (U.S.), Spec. Publ. 481, 35 pages (June 1977) Stock No. 003-003-01783-3, $1.40.

Publications listed here may be purchased at the listed price from the U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

NEWS BRIEFS

SOLAR ENERGY CONTRACTS AWARDED. NBS has awarded eight contracts for the development of model code provisions for solar energy heating and cooling systems. The contracts are funded by the Department of Energy (formerly the Energy Research and Development Administration). The purpose of the project is to provide uniform code provisions that can be adopted by local and state jurisdictions, thus assuring a basis for uniform safety and health requirements for the use of solar heating and cooling systems throughout the country. The interim provisions are expected to be completed by January 1978.

INSULATION DOES SAVE ENERGY. Public opinion surveys reveal that many people are still skeptical about the energy savings that are possible by insulating a house. An NBS study on a wood frame house in Washington, D.C., showed that adding insulation and storm windows to a house can save up to 50 percent or more in energy consumption. The addition of storm windows reduced heating requirements by 25.2 percent. The installation of insulation in the walls, ceiling, and floor reduced heating energy consumption by an additional 33.3 percent, for a total savings of 58.5 percent.

DATA ENCRYPTION HARDWARE. NBS has completed tests validating the first commercial implementation of the federal data encryption standard and has issued a validation certificate to Rockwell International for hardware developed by Rockwell's Collins Group. The hardware features a microelectronic chip, with approximately 10,000 components, capable of enciphering or deciphering 64 bits of computer data in 40 microseconds. IBM, Motorola, and other companies are also working on encryption hardware for validation under the standard.

DOLLARS DECLINE IN BASIC RESEARCH. The National Science Foundation reports that fiscal year 1976 saw another drop in constant dollars for basic science in colleges and universities. Support rose 5 percent and inflation rose 7 percent. Between 1968 and 1976, real support dropped about 5 percent for basic research while in that time applied science gained about 6 percent per year in constant dollars.

SANTA, LOOK FOR SAFETY. Toys and home playground equipment manufactured to meet voluntary safety standards will carry special Department of Commerce labels. NBS processed these standards under the Department's Voluntary Product Standards Program. As an assurance of safety, christmas shoppers are urged to look for toys labeled "Conforms to PS 72-75" and for swing sets and other such equipment labeled "Conforms to PS 66-75." No need to look for labels on bicycles, however. They must meet federal mandatory safety requirements.

NEXT MONTH IN

DIMENSIONS NBS

Your neighbor's fire could be your own—especially if you live in an apartment building or other multiple dwelling complex. Read about research and recommendations to prevent such disaster in the November issue of DIMENSIONS/NBS.

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
Sidney Harman, Under Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Acting Director

Prepared by the NBS Office of Information Activities
Washington, D.C. 20234
Robert T. Cook, Acting Chief

Richard S. Franzen, Chief, Editorial Section

Juli Kelley, Editor

Justine A. Williams, Editorial Assistant

Charles Messina, Jr., Visual Editor
(Commerce Department)

PHOTO CREDITS:

Steve Henneman: Pages 2-3.
Mark Helfer: Pages 4-5.

The National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their effective application for public benefit. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method development, and standards writing. DIMENSIONS NBS describes in technical and general terms results of NBS activity in areas of national concern such as energy conservation, fire safety, computer applications, environmental protection, materials utilization, and consumer product safety and performance. The functions of NBS are divided into four major institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology, and Institute for Computer Sciences and Technology.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $12.50, foreign, $15.65, single copy, $1.05. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.

AN EQUAL OPPORTUNITY EMPLOYER

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS

Penalty for Private Use, $300
RETURN POSTAGE GUARANTEED

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

U.S.MAIL

CONTROLLED CIRCULATION RATE

DNBS SERIA300SEISSDUE004R 1
SERIALS DEPARTMENT
XEROX UNIVERSITY MICROFILMS
300 N ZEEB RD
ANN ARBOR MI 48106